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THE STORY OF A GREAT DISCOVERY.

IT is the fate of every discovery to meet, *first*, with a flat denial of its truth, *secondly*, with a flat denial of its novelty. Science, insulted by the appearance of the Intruder, who declares that he has been overlooked, contemptuously asserts that he has been overlooked because he is an impostor. No sooner does he make good his claim to recognition, than Erudition straightway turns to its cobweb-covered folios, and points out how the sages of old were perfectly well acquainted with his existence, and that the modern patron, pluming himself on a discovery, has arrayed himself in stolen feathers.

Both these injustices have occasioned much heart-burning and sarcasm, yet both lie in the very nature of things. Science must contradict whatever contradicts it. Erudition must discover that every new idea has been anticipated; for in truth new ideas, especially when they are eminently rational or intensely absurd, are necessarily connected with speculations which have been elaborated before. Nature does not proceed *per saltum*, neither does philosophy. Every discovery is prepared. Every advance is an advance on what was before attained. There is filiation of ideas. We must not therefore recklessly assume that malice, envy, and all uncharitableness, are the only motives prompting men to rob the discoverer of his merit, by bestowing it on some earlier discoverer. The fact that each discovery is *prepared* suffices to vindicate Erudition, by furnishing it with what seems to be evidence; *seems* to be, but is not.

The discovery of the circulation of the blood is perhaps the greatest discovery of modern times in the science of life, and it will furnish us with a curious text from which to enforce the moral just laid down. It is a discovery fruitful in consequences, striking in its history, and in its history very little known: three reasons for our narrating the story in detail. To narrate it, we shall call upon the aid of M. Flourens, who has recently published a volume on the subject,* and who declares in his preface that the history had never been correctly written before he undertook it. From this, and other sources, we hope to tell the story in a style intelligible to the most unscientific reader.

The first question that occurs to the modern mind is, how the fact of circulation could so long have escaped detection? We are so familiarized with the fact, that we cannot appreciate the difficulty of its discovery. We know that when first announced, it was received with violent opposition; we know that Harvey himself declared he could find no adherent among men over forty; we know that contemporary anatomists ridiculed and 'refuted' him; but this is all incomprehensible to us, because our minds are familiarized with the truth, and not familiarized with the theories which *masked* the truth from anatomists. To tell the story of this great discovery will be to clear up such points, and show wherein lay Harvey's real merit. For it is a story, the episodes of which extend over seventeen centuries—from Galen to Harvey—and which could not have terminated earlier, nor indeed so soon, had not a regular series of discoveries prepared the way. In that long course we note the regular displacement of a series of errors by a series of truths; not until this substitution had taken place could Harvey, or any one else, have demonstrated what is now so familiar to all.

Three capital errors masked the truth, and they were these: 1. That the arteries contained *air*, not blood (hence their name, αηρ, τηρεω). 2. That the septum which divides the two chambers of the heart (called ventricles) was perforated. 3. That the veins carried the blood *to* the various parts of the body, instead of carrying it *from* the parts.

It will seem strange that matters of fact so easily observed as the two first above mentioned should have escaped the observation of anatomists, and that errors so gross

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* *Histoire de la Découverte de la Circulation du Sang.* Paris. 1854.

Methought in but brief space waxed faint the strides
 Of sire and sons. I saw the sharp fangs red
 With the rent carnage of their reeking sides.
When I awoke before the night was sped,
 I heard my children murmur in their sleep—
 For they were prisoned with me—asking bread.
The heart is hard which pity for my deep
 Foreboding anguish doth not overpower,
 And if thou weep'st not, what can make thee weep?
Now they were wakened, and drew nigh the hour
 Of food, and all with dreamborn doubts were stirred,
 When in the lower doorway of the tower
The iron clank of closing bolts I heard,
 Then silence. On my children, wistful eyed,
 Wildly I gazed and uttered not a word.
I did not weep, my vitals petrified:
 They wept. 'Thou lookest so, dear father, oh
 What aileth thee?' my little Anselm cried.
I shed no tear, and spoke not: stony woe
 Possessed me dumbly all that day and night
 Until another dawn began to grow.
Then as there straggled a few rays of light
 Into the dolorous donjon, and I knew
 From those four faces my own aspect's plight;
For them I bit my two hands through and through,
 And they, who deemed me maddened by the stress
 Of a blind ravenous desire to chew,
Suddenly rose and cried, ''Twould hurt us less
 Did you eat us! Thine be it to lay bare
 The wretched bones thyself with flesh didst dress.'
I calmed me, not to add to their despair—
 That day and yet another we were mute—
 Hard Earth, why gap'dst thou not to gulph us there?
But on the fourth day, famine's earliest fruit,
 Poor Gaddo fell. 'Oh, father, help thy son!'
 He cried, outstretched, his arms around my foot,
And there he died. Three others, one by one,
 Died on the fifth and sixth. Grown blind at last,
 I moaned the names of those whose pangs were done,
Groping from corpse to corpse. Two days thus passed
 Till over anguish hunger could prevail.'
 When he had said thus much, with eyes side-cast,
He turned the wretched scalp to reassail
 With teeth canine, that flinched not from the bone.
 Ah Pisa! shame of all the folks that dwell
In the fair clime of *si's* assenting tone,
 Since thy compeers be slow to punish thee,
 Just Heaven, remove Capraia and Gorgone
To block the throat of Arno at the sea,
 Till every soul within thy circuit drown!

G. J. C.

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should have been maintained against opposition even for a day. But the history of science is full of such singularities. A fact is not so easily recognised as men usually suppose; for facts are looked at through the coloured spectacles of the mind, named *opinions*. In Galen's time it was maintained that the air penetrated through the trachea into the arteries, which is both true and false; true as a matter of fact, false as a description of the process. The air does *not* pass from the trachea into the venous artery (or pulmonary artery as we call it), from thence to the left ventricle, and thence into the arteries; the air has *not* a system of canals appropriated to it, as the veins are appropriated to the blood, but mingles with the blood. The first step towards a true theory was taken when Galen showed that the arteries did contain blood, and did not contain air. The step may seem easy, but was not. 'If,' said his antagonists, 'the arteries do not carry the air, how is the air carried to all parts of the body?' Galen was forced to reply: 'It does not pass at all, it is respired, and thrown out again, as soon as it has performed its office.' What then is its office? The reader will smile perhaps when he hears the answer: 'The office of the air is to *cool the blood*.'

Here we see the effect of coloured spectacles. Erasistratos and his school maintaining the theory that air passed *en masse* into every part of the body, distending the arteries, and causing the pulse to beat; Galen and his school maintaining that the heart was the centre of animal heat (a doctrine only displaced by modern chemistry), the two schools had to reconcile observed fact with their theories. Moderns have overturned both theories, by proving that respiration instead of cooling the blood (as even Haller taught) is the main source of animal heat; but to the ancients such an idea would have been the wildest of absurdities.

Galen proved the arteries to contain blood as well as the veins. Here was the first step taken. But he thought that the septum of the ventricles was perforated, he said that it was so: he saw it through his coloured spectacles. His theory *wanted* the fact, and his theory *saw* the fact. Not an uncommon case.

But Galen distinguished between the two kinds of blood, venous and arterial or *spirituous*. This spirituous blood, he said, nourished the delicate organs, such as the lungs; the venous blood nourished the coarser organs, such as the liver. The spirituous element is formed only in the left ventricle, but inasmuch as even the venous blood needs some of this spirit for purposes of nutrition, it is necessary that the two bloods should mingle, and this necessity it is which proves the ventricles to communicate by means of openings. Thus because theoretical necessities demanded a perforated septum, Galen unhesitatingly declared the septum to be perforated; and because Galen said it was perforated, all the anatomists, till Vesalius, devoutly repeated it.* Vesalius, the father of modern anatomy, among his many novelties and audacities, boldly declared Galen to be wrong; and thus was the second capital error overthrown.

We now approach the third error. It is a far more complex question than the two preceding. The unity of the circulating current and the difference of the two circulating fluids are to be demonstrated. But if the two fluids do not mingle in the heart, where do they mingle? Curiously enough, the discoverer of the pulmonary circulation—that is to say of the next great step taken towards a solution of the whole problem—is none other than Michael Servetus, whom Calvin roasted for heresies of another kind; and this discovery is recorded in a work where few anatomists would think of seeking for it, a work indeed which having been persecuted with a rigour not less than that pursuing its author, has long been among the rarest of bibliopolic rarities: the

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* De Carpi naïvely says the perforations are visible only with great difficulty—*cum maxima difficultate videntur*. How he must have strained his eyes through his spectacles!

Christianismi Restitutio.[*] Servetus not only describes with accuracy the passage of the blood from one chamber of the heart through the lungs to the other chamber; he also describes the lungs as the real seat of sanguification, *i.e.*, the change from venous to arterial blood. Galen and his successors placed the seat of sanguification in the liver.

Servetus was burned; his book was burned; no one was the better for his discovery, for no one could read it. Six years afterwards, however, Padua—which has so many great anatomical names to boast of, Vesalius, Colombo, Fallopius, Fabrice d'Acquapendente, and Harvey—gloried in a professor, Realdo Colombo, who in his own way arrived at the same conclusion as Servetus;[†] and Cesalpinus, the great botanist, not only made the same discovery, but for the first time pronounced the word *circulation.*[‡]

The pulmonary circulation thus discovered, there now remained the greater difficulty, which was to discover what is now called the *general* circulation. No one had the slightest conception of it. Every one supposed the veins carried the blood *to* the tissues. Galen made the brain the origin of all the nerves, the heart the origin of all the arteries, and the liver the origin of all the veins. These veins were said to carry the blood *to* the various parts; an error which the daily practice of bloodletting ought to have destroyed, for daily must the surgeon have seen that the vein swelled *below* the ligature and not *above* it, thereby proving that the current must be towards the heart, not from it. But bloodletting preached in vain; no one observed the fact; that is to say, no one detected its significance. Cesalpinus was the first, and previous to Harvey the only, man who observed it, and recognised some of its significance: *Quia tument venæ ultrà vinculum non citrà. Debuisset autem opposito modo contingere, si motus sanguinis et spiritus à visceribus fit in totum corpus.*

It is to Cesalpinus that some historians award the merit of having first suggested the idea of the two circulations—pulmonary and systemic. De Blainville goes so far as to say, *La circulation était en grande partie connue de Césalpin bien qu'il ne l'eut pas démontrée;*[§] and he adds that the reason why Haller and others have denied this is, because they never thought of seeking it in his work *On Plants.* We pause to remark with some surprise that an anatomist of the rank of De Blainville should for a moment attach any value to an *aperçu* which he confesses 'had not been demonstrated;' and having made this remark we will give the passage as we find it in De Blainville, *Césalpin y dit,* liv. I. ch. ii., '*Car dans les animaux nous voyons l'aliment conduit par les veines au cœur comme à l'officine de la chaleur innée, et ayant acquis là sa dernière perfection, être, par les artères distribué dans tout le corps sous l'action de l'esprit, qui est engendré dans le cœur du même aliment.*' This is leagues away from the truth; and we may say of it, with Professor Bérard, that no one ought to confound two such propositions, which require demonstration and which the author himself subsequently contradicts, with the imposing mass of evidence on which Harvey founds his doctrine.[||] Nay, the Professor goes further. He maintains that so far from any one before Harvey having had a clear idea of the true theory, no one even accurately conceived the theory of pulmonary circulation. Servetus, Colombo, Cesalpinus, knew the communications which existed between the artery and the pulmonary veins, and that the blood passed by the right cavities to the left cavities. But this was only an approximation to the truth. They made no more blood pass this way than was required for the *confection des esprits vitaux.* Their predecessors thought that this small quantity passed through the perforated septum of the heart; they made it pass through the lungs. That was all. They had not the slightest idea of the torrent of blood which traverses the artery and pulmonary veins; and if they had had the idea, they would have been at a loss to say whence it came and whither it went. It was necessary to discover the entire current of circulation before the circulation of any part could be known. This just criticism suggests how cautious we should be in treating of opinions held by old writers, not to *read into* them what we ourselves understand by certain phrases.

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[*] M. Flourens gives copious extracts from this curious treatise.

[†] *De Re Anatomicâ,* p. 325 of the edition of 1572.

[‡] *Quæstion. Peripatet.,* lib. v. p. 125, edit. of 1593. Flourens gives the passage.

[§] *Histoire des Sciences de l'Organization,* ii. p. 227.

[||] *Cours de Physiologie,* iii. p. 581.

The true explanation was still distant—unsuspected. One anatomical discovery suddenly brought it nearer. Fabrice d'Acquapendente, in 1574, discovered that the veins had *valves.* He saw that they were turned towards the heart. It may seem strange that Fabrice should not have seen in this discovery the anatomical proof of circulation; for if the valves prevent the blood coming *from* the heart, and allow it to pass *to* the heart, the old doctrine of the veins being the carriers of blood to the tissues is upset. Fabrice saw the fact; the significance of the fact was seen by Harvey, and by him alone.*

And now the final step was to be taken; a man of genius came to put an end to these arduous and fluctuating tentatives, and to reveal the mystery which for seventeen centuries had baffled the wisest. In 1619, William Harvey publicly taught the doctrine which, with slight modifications, has been taught ever since; and in 1628 he published his treatise, *Exercitatio Anatomica de Motu Cordis et Sanguinis,* which forms the basis of modern physiology. The history of previous attempts, and the exposition of the state of doctrine when Harvey appeared, give a profounder impression of the magnitude of his discovery and the genius it required, although they enable us to trace how that discovery was prepared; they show what was the confluence of ideas which made the discovery *possible* then, and they show the force of mind needed before advantage could be taken of such confluence: they give to the Hour and to the Man respective shares. A little earlier, the discovery would have been impossible; a little later, it would assuredly have been made by some one else. Before the valves in the veins had been discovered, the idea of circulation would always have been rejected as absurd; but the importance of these valves would not have been perceived, had not the old error of a perforated septum been removed; and thus we remount from Harvey to Acquapendente, from Acquapendente to Cesalpinus, Colombo, and Servetus, from them to Vesalius, from Vesalius to Galen —so many landmarks on the long and weary way—so many ancestors in the parentage of a great idea.

M. Flourens, whose admiration for Harvey is unstinted, says that, when Harvey appeared, *tout avait été indiqué ou soupçonné; rien n'était établi.* We think this less than the truth. We think it can be shown in the clearest manner that no one had the slightest conception of the circulation, not even as a possible process. And yet we have shown how the discovery was *prepared;* we have shown that Harvey appeared at a certain juncture and confluence of time when the discovery became possible. That the idea was startling in its novelty, and would excite boundless opposition, Harvey knew: *Adeo iis nova erunt et inaudita,* he says, *ut non solum ex invidia querundam metuam malum mihi, sed vereor ne habeam inimicos omnes homines, tantum consuetudo aut semel inhibita doctrina, altisque defixa radicibus, quasi altera natura apud omnes valet, et antiquitatis veneranda opinio cogit.*† One proof will suffice. The last step which was taken before Harvey was taken by Harvey's master, Acquapendente. In discovering the venous valves he discovered the mechanism which permitted circulation. But we have seen that he failed to perceive its true bearing; he said, indeed, that the purpose of the valves was to prevent the accumulation of blood in the lower parts of the body! Nay, more: this discovery was made in 1574; forty-five years elapsed before its real significance was appreciated, and during these five-and-forty years all that was known, all that was suspected touching the circulation of the blood, was known to every anatomist in Padua, if not in Europe; and it was in Padua Harvey studied. It is clear then that Harvey discovered what was new, what was unsuspected; and any attempt to rob him of that glory must be silenced by a decisive verdict.

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* M. Flourens examines at some length the claim of Paolo Sarpi to the discovery made by Harvey, and decides that there is absolutely *no* evidence in favour of Sarpi. To what he has said we may add the testimony of George Ent, Harvey's friend, who declares the Venetian Ambassador at London witnessed Harvey's demonstration, and told Sarpi of it.

† *Exercitatio,* p. 80.

A natural question arises: how did the ancients conceive the movement of the blood to take place, if circulation was an idea of which they had no suspicion? The answer is: they believed the blood to oscillate to and fro in the veins, with a sort of flux and reflux like the ebb and flow of the tides. The discovery of a *circulus*—that all the blood flowed from the heart through the arteries, and returned back again to the heart through the veins—changed the whole aspect of physiology. Harvey left, however, much to be done by successors in filling up the outline he conceived. He knew nothing, for instance, of the capillaries, those minute delicate vessels which form the termination of arteries and the commencement of veins—channels by which arterial blood is conveyed into the veins. He knew that the blood did pass from artery to vein, but knew not whether it passed through the direct union of the two vessels in anastomosis, or through the porosities of the flesh, *aut porositates carnis et partium solidarum pervias sanguini.* The microscope had not then revealed the capillaries—which we call hair-like vessels, although hairs are thick as cables in comparison with vessels invisible to the naked eye. They were not seen till 1688 by Leeuwenhoek.

The opposition with which Harvey's discovery was met, has become a stereotyped theme of declamation, but it is less generally known that Harvey himself opposed to the last the important discoveries of the lacteals and lymphatics, vessels which are absolutely necessary to complete his own theory; a fact which helps us to understand the opposition raised by scientific men to discoveries they have not made, and to doctrines they have not been taught.

G. H. L.

THE PAST SESSION.

IT is not our intention to undertake a regular review of the past session of Parliament. We are deterred however from such a task not by the magnitude of the subject or the multitude of the topics, but from the opposite reasons. There is hardly anything to review; scarcely a legislative labour which affords any scope for comment or discussion. The men who should write worthily upon the session of 1855, had need of the pen of Swift, who could discourse copiously upon a broomstick.

The truth is, little or nothing has been done. For this result, the Government of course are blamed, though in fact they are blameless, because they were helpless in the matter. The House of Commons, justly representing the country in this respect, would think or talk of nothing but the war. It is a good old maxim of English justice and common sense, that the Government shall be praised or blamed for everything that goes right or wrong, without any regard to such an abstruse and remote question as the connexion of the said Government with the temporary causes of good or evil. Whether the admiral at the seat of war neglects to blockade the enemy's coast, or the general overlooks the necessity of establish-